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CHEMICAL RESEARCH, DEVELOPMENT & ENGINEERING CENTER

CRDEC-TR-047



# TOXICITY OF JET A TO SELECTED AQUATIC ORGANISMS

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March 1989





U.S. ARMY ARMAMENT MUNITIONS CHEMICAL COMMAND

Aberdeen Proving Ground, Maryland 21010-5423

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# REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

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| 4. PERFORMING ORGANIZATION REPORT NUMBER(S)<br>CRDEC-TR-047 | 5. MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a. NAME OF PERFORMING ORGANIZATION<br>CRDEC<br>6b. OFFICE SYMBOL (If applicable)<br>SMCCR-RST | 7a. NAME OF MONITORING ORGANIZATION |
| 6c. ADDRESS (City, State, and ZIP Code)<br>Aberdeen Proving Ground, MD 21010-5423 | 7b. ADDRESS (City, State, and ZIP Code) |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION<br>CRDEC<br>8b. OFFICE SYMBOL (If applicable)<br>SMCCR-RST | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER |
| 8c. ADDRESS (City, State, and ZIP Code)<br>Aberdeen Proving Ground, MD 21010-5423 | 10. SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO.: <br>PROJECT NO.: 1C162622<br>TASK NO.: A552<br>WORK UNIT ACCESSION NO.: |

11. TITLE (Include Security Classification)
Toxicity of Jet A to Selected Aquatic Organisms

12. PERSONAL AUTHOR(S)
Haley, Mark V., and Landis, Wayne G.

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| Technical | FROM 87 Aug TO 88 Feb | 1989 March | 13 |

16. SUPPLEMENTARY NOTATION
Contd from Pg. 7

| 17. COSATI CODES | | |
|---|---|---|
| FIELD | GROUP | SUB-GROUP |
| 24 | 07.04 | |
| | | |

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
JP8 (jet propulsion)
Jet A (aviation fuel)
Aquatic toxicology
Daphnia magna
Selenastrum capricornutum

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
The aquatic toxicity of the soluble fraction of Jet A (aviation fuel) was examined. Acute 48-hr bioassays were performed using the water flea, Daphnia magna, and 96-hr growth inhibition bioassays were performed using a green unicellular alga, Selenastrum capricornutum. All tests were conducted according to guidelines set by the U.S. Environmental Protection Agency (EPA) and the American Society for Testing and Materials (ASTM). The 48-hr $EC_{50}$ for D. magna was 3.1 mg/L. The 96-hr $IC_{50}$ for S. capricornutum was 4.2 mg/L.

| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT | 21. ABSTRACT SECURITY CLASSIFICATION |
|---|---|
| ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS | UNCLASSIFIED |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>SANDRA J. JOHNSON | 22b. TELEPHONE (Include Area Code)<br>(301) 671-2914<br>22c. OFFICE SYMBOL<br>SMCCR-SPS-T |

DD Form 1473, JUN 86 *Previous editions are obsolete.*

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

## PREFACE

The work described in this report was authorized under Project No. 1C162622A552, Smoke and Obscurants. This work was started in August 1987 and completed in February 1988.

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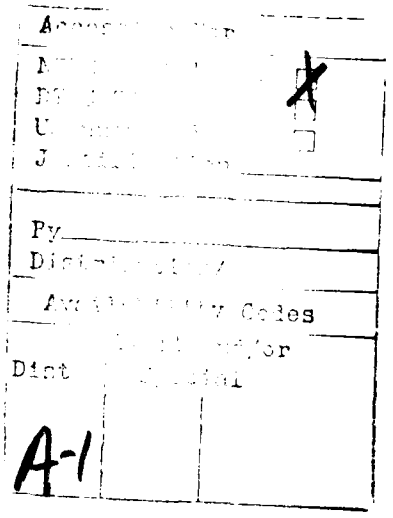


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# TOXICITY OF JET A TO SELECTED AQUATIC ORGANISMS

## 1. INTRODUCTION

JP8 (jet propulsion) is an aviation fuel being considered for replacement of diesel fuel used in the generation of smoke on the battlefield.[1] JP8 is projected to be more economical and also be used as a fuel for the ground machinery used in the transport and dissemination of JP8. Also, fog oil has naphthene constituents above the Occupational Safety and Health Administration (OSHA) standards. JP8 trailing and testing could lead to contaminating surrounding aquatic ecosystems through runoff or wind transport. Therefore, the toxicity of JP8 to aquatic organisms must be known.

Jet A (aviation fuel) was substituted for JP8 due to availability and similar distillation procedure,[1] Sample ID number (AL-15423-F) Jet A was the particular cut used in these studies. This sample of Jet A contained 75% bottom distillation products.

This study was conducted to examine the toxicity of Jet A to Daphnia magna (the water flea) and Selenastrum capricornutum (a green unicellular algae). Jet A is a kerosene type aviation fuel consisting of alphatic and aromatic hydrocarbons.[2] Only the water soluble fraction of Jet A was used as the toxicant.

## 2. METHODS AND MATERIALS

Jet A (AL-15423-F) was obtained from Dr. Sandra Thomson of the Toxicology Division, Research Directorate, U.S. Army Chemical Research, Development and Engineering Center.

Twenty-five milliliters of Jet A were placed into a 1000-mL separatory funnel and filled with diluent. Turbulent mixing can cause increased droplet suspension, therefore, not yielding a true dissolved solution as Boylan and Tripp have shown in their studies.[2] The funnel was inverted slowly 10 times and allowed to stand for 3 hr to ensure complete separation. The solubilized portion of Jet A was withdrawn and used in the toxicity tests. A sample of the dissolved fraction was sent to the U.S. Army Environmental Hygiene Agency for analysis of total hydrocarbons via gas chromatography. All the tests conformed to current guidelines set by the American Society for Testing and Materials (ASTM),[4] and U.S. Environmental Protection Agency (EPA).[5]

D. magna were obtained from Dr. Freda Taub from the University of Washington in Seattle. Daphnia were reared in the laboratory as described by Goulden et. al.[6] The culture media was prepared from municipal drinking water that was hardened to 132 ppM total $CaCO_3$.[4] The pH ranged from 7.2 to 7.8. Neonates of less than 24 hr old were placed into 250-mL glass beakers filled with 100 mL of the test solution. The test beakers were placed into an incubator with a light-dark cycle of 16/8 hr with 315 ft candles of light, at a temperature of 20 °C. The test concentrations ranged from 0.37 to 5.7 mg/L Jet A. Immobilization was recorded at 24 and 48 hr. The $EC_{50}$ (the effective concentration at which 50% of the organisms are immobilized) values were computed using the probit analysis as prepared by Stephan (conversation with

C.E. Stephan, USEPA, Duluth, MN, June 1984). S. capricornutum was obtained from the American Type Culture Collection (No. 22662). Stock cultures of algae were maintained on 1.5% Difco-Bacto agar slants. Test algae were grown in a semi-flow through culture apparatus6 and taken during log phase growth for inoculation into the test flasks. Five hundred milliliter Erlenmyer flasks with ground glass stoppers were used as test chambers. One hundred milliliters of media were placed in each test chamber and inoculated with approximately $4.0 \times 10^4$ algal cells per milliliter. Test concentrations ranged from 0.37 to 5.7 mg/L Jet A. The algae were placed in an incubator under the same conditions as described above. Using a Neubauer counting chamber, cell densities were determined every 24 hr for five consecutive days. $IC_{50}$ determinations (the concentration at which algal growth is inhibited to 50% of the control growth) were derived graphically.

## 3. RESULTS

After allowing the Jet A to separate in a separatory funnel for 3 hr, 5.7 $\pm$ 0.2 mg/L had dissolved into the water column.

The algae was the least effected by Jet A and had a 96-hr $IC_{50}$ = 4.2 mg/L (Figure 1).

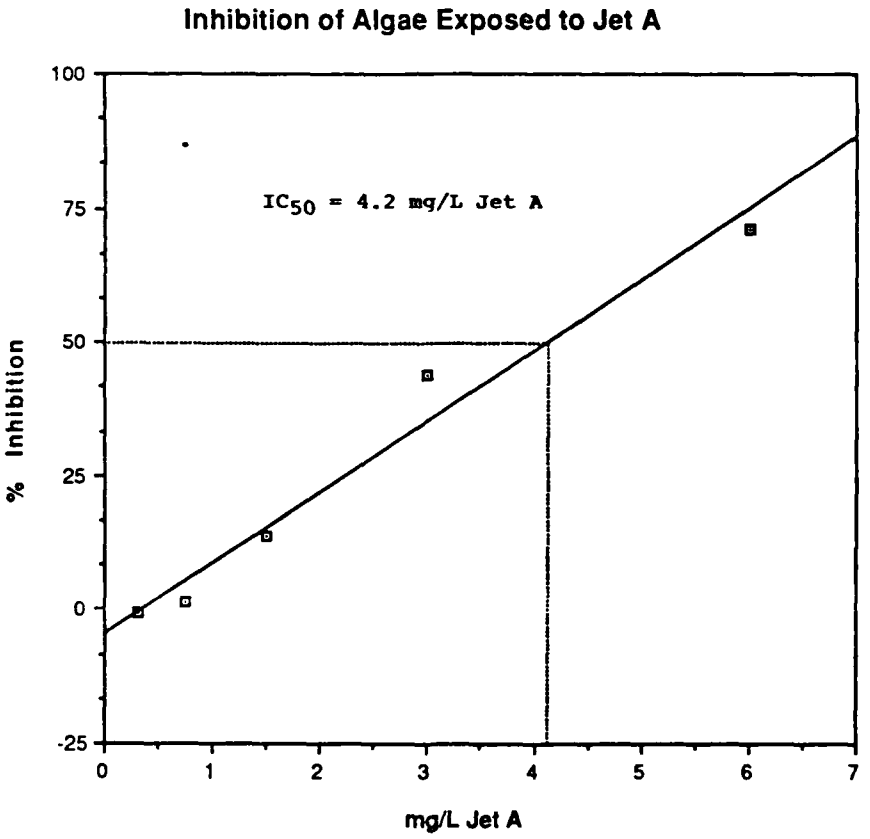


Figure 1. $IC_{50}$ Determination for Selenastrium capricornutum Exposed to Jet A (AL-15423-F)

The highest concentration of Jet A (5.7 mg/L) decreased algal growth significantly ($p \leq 0.05$). The lowest concentration (0.37 mg/L) simulated algal growth slightly higher than the control growth (Figure 2).

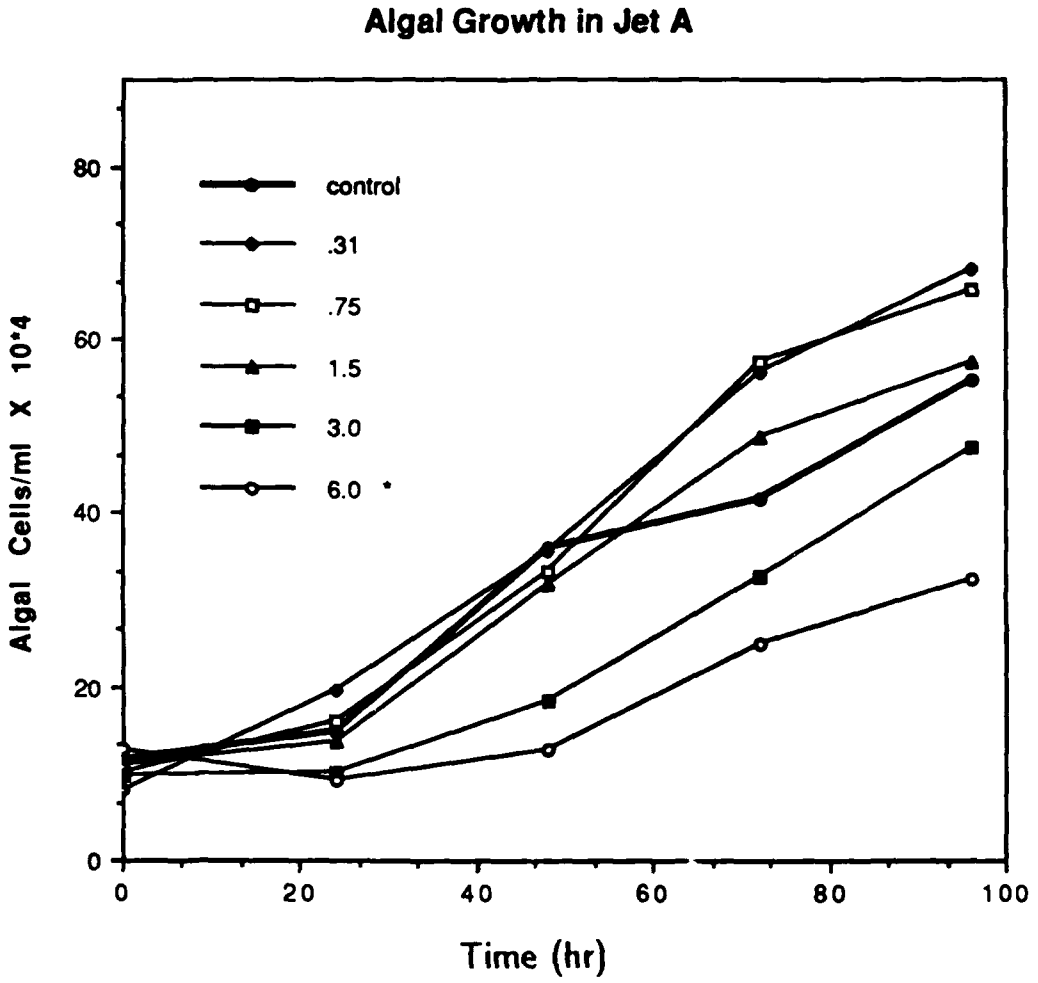


Figure 2. Growth Curves of Selenastrum capricornutum Exposed to Jet A (AL-15423-F)

Daphnia were more sensitive to Jet A and had a 48-hr $EC_{50}$ = 3.5 mg/L (Figure 3). The higher concentrations (1.5 - 3.0 mg/L) of Jet A caused daphnia to float on the surface.

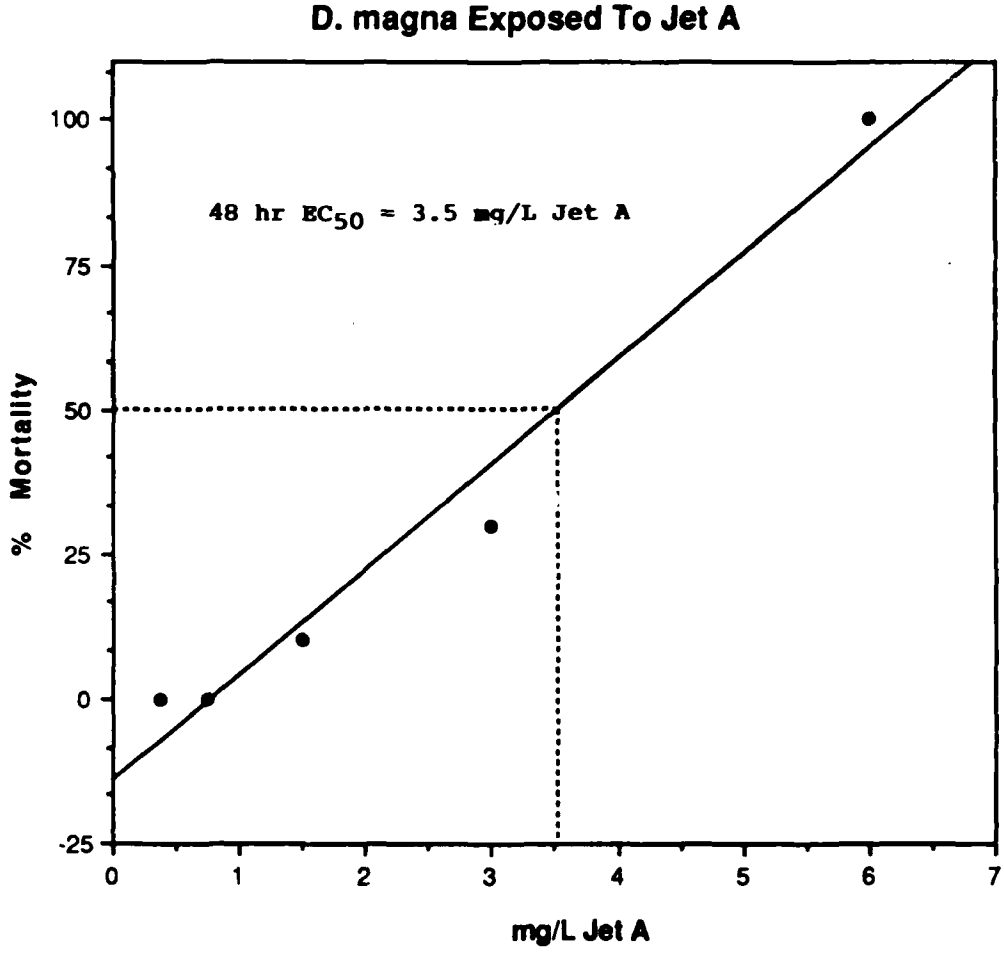


Figure 3. $EC_{50}$ Determination of Daphnia magna Exposed to Jet A (AL-15423-F)

4. DISCUSSION

Jet A and JP8 are petroleum derived kerosene type fuels. In petroleum products, there is a high concentration of polycyclic aromatic hydrocarbons that include benzenes and naphthalenes. However, preparing the soluble fractions of petroleum can yield varying results. Lee and Craig6 report having no napthalenes identified in their analysis of crude oil that isolated only the low boiling point components. Yet, Boylan and Tripp3 identify napthalenes in kerosene and crude oil. They also showed that kerosene had a much higher concentration of napthalenes that isolated the higher boiling point components. A literature search did not reveal any information on the chemical analysis of napthalenes or benzenes contained in JP8 or Jet A. Therefore, only assumptions can be made to the chemical content of the toxicant.

A concentration of 5.7 mg/L of Jet A caused 100% mortality to daphnia in less than 3 hr and caused a significant decrease in algal growth. The sensitivity of the test organisms to Jet A suggest that an aquatic

ecosystem would be severely impacted. Considering the physical dispersion, via wind and wave action, or tidal flushing, would dilute the spill, there could be enough localized damage to severely disrupt the natural food chain. Melancon and Lech[8] found that naphthalenes accumulate in trout tissues 300 to 23,500 times the water concentration, depending on which tissue was looked at. After 15 days, the tissue levels still were not back to base line. This could result in biomagnification, thus causing an impact on human consumption. In an enclosed aquatic system such as a pond, a spill of Jet A would cause long-term effects that would not be resolved until degradative processes reduce the concentrations to below harmful levels.

Using a scoring criteria for aquatic toxicity developed by O'Bryan[9] (unpublished data, February 1986) that ranks toxicity from 1 - 10 with 10 being the most toxic, Jet A would be ranked 7.

Fielding and testing Jet A during military training exercises may impose serious impact on the surrounding aquatic ecosystems. Several pathways exist for Jet A to enter an aquatic system. Weather conditions may cause uncontrolled dispersion of the smoke screen. Any accidental spills during smoke generator refills and deposits on surrounding vegetation can be introduced in the surrounding water shed via rain water runoff.

## 5. CONCLUSIONS

The fielding of Jet A may cause serious damage to an aquatic ecosystem. The possibility exists that wind or rain water runoff can cause Jet A to be introduced into the surrounding bodies of water. The toxicity of Jet A is ranked 7 on a scale of 1-10, with 10 being the most toxic, using daphnia and algae as test organisms. Daphnia were more sensitive to Jet A than S. capricornutum. Extreme caution should be used to prevent spills or runoff when field testing Jet A.

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## LITERATURE CITED


1. Wimer, W.W., Wright, B.R., Kanakia, M.D., A Study Relating to The Fog Oil Replacement Program, Interm Report BFLRF No. 241, U.S. Army Belvoir Research, Development and Engineering Center, Materials, Fuels and Lubricants Laboratory, Fort Belvoir, VA, September 1987, UNCLASSIFIED Report.

2. Smith, L.H., Daugherty, M.L., Pruett, J.G., The Toxicity of Diesel Fuels, Fog Oils and JP-8 Aviation Fuels in Mammals and Environmental Species, Contract No. DE-AC05-840R21400, Oak Ridge National Laboratory, Oak Ridge, TN, March 1987, UNCLASSIFIED Report.

3. Boylan, D.B., and Tripp, B.W., "Determination of Hydrocarbons in Seawater Extracts of Crude Oil and Crude Oil Fractions," Nature Vol. 230, No. 5288, pp 44-47 (1971).

4. Guide for Conducting Acute Toxicity Tests with Fishes, Macro-invertebrates and Amphibians, Standard E729, American Society for Testing and Materials, Philadelphia, PA, 1986.

5. Users Guide: Procedures for Conducting Daphnia Magna Toxicity Bioassays, EPA-660/8/878/011, U.S. Environmental Protection Agency, Washington, DC, March 1987.

6. Goulden, C.E., Comotto, R.M., Hendrickson, J.A., Jr., Hornig, L.L., and Johnson, K.L., Proceeding and Recommendations for the Culture and Use of Daphnia Magna in Bioassay Studies, ASTM Special Technical Report Publication No. 766, American Society for Testing and Materials, Philadelphia, PA, April 1982.

7. Lee, C.C., Craig, W.K., "Water Soluble Hydrocarbons from Crude Oil," Environmental Contamination and Toxicology Vol. 12, No. 2, pp 212-217 (1974).

8. Melancon, J.M., and Leach, J.J., "Distribution and Elimination of Naphthalene and 2-Methylnaphthalene in Rainbow Trout During Short and Long Term Exposures," Environmental Contamination and Toxicology Vol. 7, No. 2, pp 207-220 (1978).